Comparison of 2 vegetation-height management practices for wildlife control at airports

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Human–Wildlife Conflicts 1(1):97–105, Spring 2007

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Abstract: Vegetation-height management is a potential method to reduce bird numbers at airports. Based on studies in Europe, researchers recommended vegetation heights around 25 cm; however, preliminary studies in the United States produced conflicting results regarding the effect of tall (18 to >25 cm) vegetation on bird numbers at airports. From 1999 to 2002, we compared birds and other wildlife use of 4 short-vegetation plots (mean maximum height of 15.6 cm ± 5.1 SE and visual obstruction reading of 4.6 ± 3.0 cm) and 4 tall-vegetation plots (mean maximum height of 26.9 ± 8.4 cm and visual obstruction reading of 10.0 ± 5.0 cm) in Ohio. We surveyed bird use of the plots 2 to 3 times/week and observed 6,191 birds in short-vegetation plots and 5,962 birds in tall-vegetation plots. We detected no difference between short-vegetation and tall-vegetation plots in the probability of avian use of the plots when evaluated as a binary response of presence and absence. Small mammal capture rates in 100 adjusted trap nights were 0.0 in short-vegetation plots and 0.3 in tall-vegetation plots. We found no difference in the number of deer observed in the plots during sunset and spotlighting counts. There was slightly greater insect biomass in tall- than in short-vegetation plots. Mowing negatively affected small mammal use. The generalization that tall vegetation (18 to >25 cm) alone would reduce bird use of an airport is not supported by the results of this study. Further research on vegetation density, composition, palatability, and nutritional value is necessary to accommodate airfield requirements for habitat that is pleasing to the public and repellent to wildlife.

Key words: aircraft–bird hazard, airport management, bird–aircraft collisions, bird strike, eastern meadowlark, European starling, human–wildlife conflict, *Sturnella magna*, *Sturnus vulgaris,* wildlife hazard

When mammals and birds collide with aircraft they pose serious safety hazards to people. Additionally, aircraft-bird collisions (i.e., bird strikes) cost the U.S. civil aviation industry > $496 million annually and resulted in 9 fatalities from 1990 to 2004 (Cleary et al. 2005). Approximately 78% of all bird strikes occur < 244 m above ground level (AGL) and 90% occur < 610 m AGL (Cleary et al. 2005). Gulls (*Larus* spp.), waterfowl such as Canada geese (*Branta canadensis*), hawks (Falconiformes), owls (Strigiformes), blackbirds (Icteridae), and European starlings (*Sturnus vulgaris*) are the species of great concern at U.S. airports (Wright et al. 1998, Dolbeer et al. 2000, Wright 2001, Cleary et al. 2005, Blackwell and Wright 2006). Management techniques that reduce bird use of habitats on and around airports are therefore critical for safe airport operations.

Habitat management provides a nonlethal technique for reducing bird use of airports and other areas where birds pose problems. One method often suggested for reducing bird numbers at airports is to maintain tall vegetation (18 to >25 cm), as opposed to standard mowing practices that maintained short vegetation (5–10 cm; U.S. Department of Transportation 1993, Transport Canada 1994, U.S. Department of Agriculture 1998, Civil Aviation Authority 2002). Tall vegetation is thought to interfere with visibility and ground movements of flocking birds such as European starlings and gulls (Solman 1966, Blokpoel 1976, U.S. Department of Transportation 1993, Transport Canada 1994, Dekker and van der Zee 1996, U.S. Department of Agriculture 1998). The U.S. Air Force implemented a policy (AFI91-202) in 1998 requiring vegetation to be maintained at 18 to 36 cm tall when possible. The basis for these recommendations comes from studies conducted in Great Britain (Mead and Carter 1973, Brough and Bridgman 1980), where the bird species of concern in the United States were not present. For example, there is limited data on how Canada geese and various raptors that are significant problem species on many U.S. airports react to tall-vegetation management. In addition, tall-grass management in Great Britain involves a rigorous regimen of mowing, thatch and weed removal, and the use of fertilizers to maintain an erect, dense stand of grass (Civil Aviation Authority 2002). This type of vegetation management is not generally practiced on United States airfields because previous studies on tall-vegetation management at airports in the United States have produced conflicting results (Buckley and McCarthy 1994, Seamans et al. 1999, Barras et al. 2000). Additionally, tall vegetation at airports may be undesirable from aesthetic and security viewpoints, particularly if benefits of such management are questionable.

Our study included observations of bird and mammal activity in vegetation plots maintained within set height ranges. Our objective was to determine if bird and mammal use of plots differs due to vegetation height. Our goal was to provide airport personnel with objective recommendations for vegetation management to minimize bird and other wildlife strikes.

Methods

We conducted our study from May 1999 through July 2002 at the National Aeronautics and Space Administration's Plum Brook Station (PBS), Erie County, Ohio (41°37′N, 82°66′W). The 2,200-ha facility is enclosed by a 2.4-m-high chain-link fence with barbed-wire outriggers. Habitat within PBS differed from the surrounding agricultural and urban area and consisted of dogwood (*Cornus* spp., 39%), grasslands (31%), open woodlands (15%), and mixed hardwood forests (11%; Rose and Harder 1985). Birds commonly observed at PBS include American goldfinch (*Carduelis tristis*), American robin (*Turdus migratorius*), Canada goose, eastern meadowlark (*Sturnella magna*), European starling, and red-tailed hawk (*Buteo jamaicensis*). The vegetation management regime we followed simulated that of airport field management.

In May 1999, we established 8 circular plots, each 1.5-ha and all ≥ 0.4 km apart from each other. We randomly assigned 4 plots each to treatments of short vegetation (9–15 cm) or tall vegetation (15–30 cm) management. When plots exceeded their maximum height (15 cm for short and 30 cm for tall), we mowed the plot to their minimum assigned height (9 cm for short and 15 cm for tall). Due to equipment limitations, 9 cm was the shortest we could mow, but this simulated mowing at airports practicing short-grass management.

Bird surveys

We began bird surveys on July 23, 1999, and conducted surveys 2 to 3 days/week starting at randomly-chosen plots and times from sunrise to sunset. We conducted 2 rounds of observations approximately 1 hour apart during each observation period, such that when the first survey or round of all 8 plots was completed, we immediately began a second round of surveys. We observed each plot for 5 minutes from a fixed point <30 m outside of the plot. We counted the number of birds and mammals by species that we observed on the ground in the plot, within 1 m of its edge, or flying over the plot. By the end of the first growing season, we recognized that we could not see all birds in the plots due to the vegetation height. Therefore, during May 2000 we initiated flush counts of each plot once every 2 weeks (May to November) to account for birds that were in plots but blocked from our view by vegetation. We conducted flush counts after the second-round observation was completed on a plot. Prior to entering the plot, we counted all birds in the plot, and then 2 people walked circular paths through the plot 30 and 40 m from the perimeter, respectively. When possible, a third person observed the plot to count flushed birds and look for new birds entering the plot after initiation of the count. We did not record any birds that flew into the plot after the flush count had started.

Plot vegetation

Despite proximity and moving regimens for our plots, we could not be sure that plant composition and structure would be approximately homogeneous within treatment. Therefore, we measured vegetation height weekly from July 26 to October 21, 1999, April 10 to October 23, 2000, April 23 to October 9, 2001, and April 22 to July 22, 2002. Vegetation measurements began at the start of the study (July 26, 1999), when grasses started growing in the spring, and we ceased measuring at the end of the growing season (i.e., first killing frost) when the study ended (2002). We selected 10 sample points from the center of each plot along a randomly selected compass heading using a random numbers table. At each sample point, we measured the maximum vegetation height by placing 2-m sticks vertically 1.5 m apart with a string connecting the sticks and in line with the compass heading. We kept the string parallel to the ground and adjusted its height to the top of the tallest plant under the string and recorded the distance from the string to the ground. We determined an index of density of the vegetation or visual obstruction reading (VOR) by an observer always standing 3 m from one of the meter sticks and looking at the meter stick from a height of 1.5 m to determine the lowest cm number visible on the stick. This measurement was then repeated with the other meter stick and a mean VOR value in cm was calculated. We sampled vegetative composition at 6 set points along the 1.5-m string used to measure vegetation height. We classified the plant immediately below each set point into one of the following categories: moss, fern/horsetail, grass/sedge/rush, forb, coniferous woody, broadleaf woody, non-grass monocot, lichen, or bare ground.

Mammals

We quantified small mammal abundance by snap trapping at all sites for 3 nights in March and October 2000 and 2001 and in March 2002. In March 2000, we created 5 100-m trapping lines with each line 10 m apart. This trapping grid was centered in each plot. We placed mouse snap traps (4.5 x 9.5 cm) at 10-m intervals along each trap line (50 traps/plot). We also placed 1 rat snap trap (8.5 x 17.5 cm)/ trap line (10 traps/plot) 1 m from a randomly selected mousetrap. Each trap was baited with a peanut butter-oat mixture. Beginning in October 2000, we modified our procedure by modifying the rat traps and using only these at each trap location along 5 trap lines. Rat traps were modified by adding a second killing bar to each trap that came down either on or adjacent to the trap treadle such that the distance from the treadle center to the added bar was similar to that of a standard mouse trap. We checked traps each morning, re-baited when required, and identified all captured mammals to species. We defined capture rate as the number of animals caught/100 adjusted trap nights. Trap nights were defined as 0.5 nights for traps that were missing, had all bait removed, or had sprung, and 1.0 night for unsprung traps that were still baited.

We made visual counts monthly of medium-sized mammals in each plot. We conducted 2 sets of observations with the first set starting 30 minutes before sunset and ending at sunset (hereafter called the sunset period) and the second set starting 30 minutes after sunset and ending 1 hour after sunset (the night period). During the sunset period, we used binoculars from our bird observation points to identify and count all mammals in or within 1 m of the plot. Once during each night period, we turned on a 1-million-candle-power spotlight from the bird observation points to search for and identify mammals in or adjacent to each plot.

Arthropods

As with vegetation structure and composition, arthropod presence could contribute to differential use by birds within and between treatment. Therefore, we sampled arthropod abundance monthly in each plot from May to September 2000 and 2001 using 0.4-m sweep nets. Two random transects, each 138 m long, were selected through the center of each plot. We conducted sweeps by walking slowly along each transect and sweeping the net through vegetation parallel to the transect heading. We put the contents of the sweep net into a plastic bag and then into a freezer until the arthropods could be categorized by taxonomic group, counted, and a dry weight could be taken.

Analysis

Our sample size precluded the inclusion of arthropod presence and vegetation characteristics other than height as model parameters. These data were used simply as qualitative descriptors of the plots. However, we modeled the probability that use of plots by an avian group was based on our treatment: short- versus tall-vegetation management. We evaluated goodness of fit of the model as a binary response (i.e., group observed in plot = 1 versus group not observed in plot = 0) under the PROC GENMOD Procedure (SAS Institute 2001) using repeated measures logistic regression on the binary data via Generalized Estimating Equations (GEE; Zeger and Liang 1986, SAS Institute 2001). Under the GEE method, an actual covariance structure specific to the within-subject (i.e., plot) variance is not calculated; instead one selects a working correlation structure that best fits the assumptions concerning correlations of variance terms within subject (Hedeker and Gibbons 2006). Because of our sample size within treatment ($n = 4$ plots) and, subsequently, the likelihood that we would not be able to accurately account for seasonal variation in group use, we selected an exchangeable correlation structure, essentially assuming compound symmetry. The GENMOD procedure then allows use of the variance function for the binomial distribution (e.g., when analyzing binary data), and the GEE method accounts for correlations among observations on the same subject (i.e., plot) by regressing parameters assuming that the observations are independent. The residuals from the model regression are then used to estimate Pearson residuals (correlation residuals) among observations from the same subjects, and the correlation residual estimates are used to obtain new estimates of the regression parameters (i.e., the intercept and treatment for our model). The process is repeated until the change between the 2 successive estimates is very small (i.e., they converge; SAS Institute 2001, Hedeker and Gibbons 2006). We applied this analysis only to those species that were common in our plots.

We analyzed our mammal capture and observation data using Kruskal-Wallis 1-way analysis of variance. We used an alpha level of 0.05 for all statistical tests. The National Wildlife Research Center Institutional Animal Care and Use Committee approved procedures involving birds and mammals before the start of the study (QA-638).

Results

Vegetation

From 1999 to 2002, each of the 4 short- and 4 tall-vegetation plots was mowed a mean of 11.6 and 6.0 times/year, respectively. The overall mean (± SE) maximum vegetation height for short-vegetation plots was 15.6 ± 0.1 cm and 26.9 ± 0.1 cm for tall-vegetation plots for all years combined. The overall VOR for short plots was 4.6 ± 0.1 cm and for tall plots was 10.0 ± 0.1 cm. Dominant vegetation types in both treatments were forbs, grasses, and woody plants (Figure 1).

Birds

From July 23, 1999, to July 25, 2002, we observed 68 and 78 bird species either in, adjacent to, or flying over short- and tall-vegetation plots. The birds were seen during 627 observation periods per plot on 314 days. Thirty-seven species were observed on the ground in both short- and tall-vegetation plots. We observed 6,191 birds on the ground in short-vegetation plots and 5,962 birds in tall-vegetation plots (Table 1).

Notably, there was a single count of 4,000 common grackles (*Quiscalus quiscula*) in a tall plot on 1 count, accounting for 67 % of the total number of birds observed in tall-vegetation plots.

In 33 flush counts, we flushed more ($Z = 3.46$; $P < 0.01$) unseen birds from tall-vegetation plots (111 birds) than short-vegetation plots (63 birds). European starlings, eastern meadowlarks, and field sparrows (*Spizella pusilla*) were the most common species flushed from the plots but not seen or counted during the observation time (Figure 2).

We limited our Type III GEE analysis to American robins, eastern meadowlarks, European starlings, blackbirds (brown-headed cowbirds (*Molothrus ater*), red-winged blackbirds (*Agelaius phoeniceus*), and common

Table 1. Number of birds observed in tall-vegetation (tall veg.) plots during 2,508 observation periods and number of observations in short-vegetation (short veg.) plots during an equal number of observation periods. The percentage of observation periods when a species was observed in the plot also is shown (% occurrence).

	Number of birds		% occurrence	
Species	Tall veg.	Short veg.	Tall veg.	Short veg.
Common grackle	4,049	30	0.4	0.6
European starling	537	2,383	2.4	8.5
American robin	231	2,660	1.6	12.3
Red-winged blackbird	123	171	2.6	2.9
Eastern meadowlark	704	238	13.1	4.9
Northern flicker	39	154	3.9	3.2
All species	5,962	6,191	26.7	42.3
No birds present	—	—	73.3	57.7

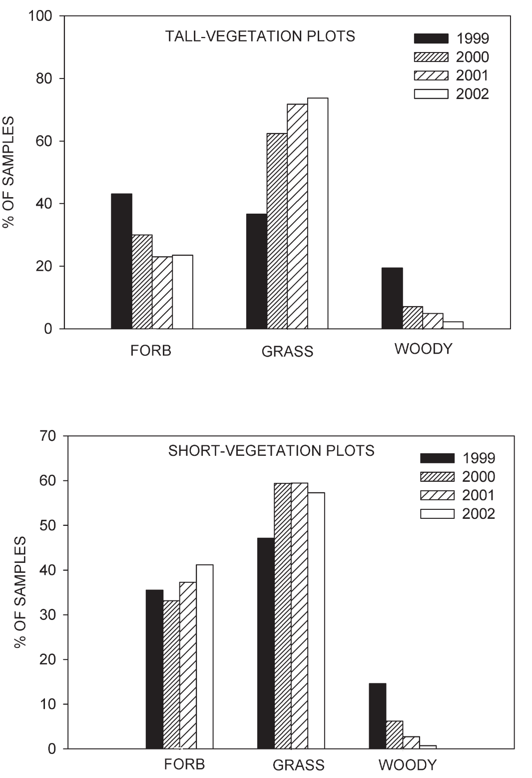

Figure 1. The percentage of vegetation types found in tall- and short-vegetation plots at Plum Brook Station, Erie County, Ohio, 1999–2002.

Table 2. Contribution of model parameter and treatment (tall- versus short-vegetation[a]), in explaining presence or absence of a species within vegetation plots, Plum Brook Station, Erie County, Ohio, 1999–2002.

Group	Correlation[b]		Type III GEE Analysis[c]		
	Empirical	Model based	Estimate	χ^2	P
American robin	-0.8595	-0.9191	2.0232	6.84	0.01[d]
Blackbird[e]	-0.6683	-0.7369	0.2236	0.10	0.76
Eastern meadowlark	-0.8239	-0.5609	-1.0058	2.48	0.12
European starling	-0.7969	-0.8626	1.2578	2.65	0.10
Northern flicker	-0.8216	-0.8634	1.1570	2.31	0.13
Hazards[f]	-0.7623	-0.6771	-0.2191	0.21	0.65

[a]Short vegetation = 9–15 cm; tall vegetation = 15–30 cm.
[b]Model-based correlation structure for the parameter, treatment, for correlations among observations on a specific plot was designated as exchangeable.
[c]Type III contrasts were computed on the effect of treatment using Generalized Estimating Equations (SAS Institute 1999). One degree of freedom was associated with each group-specific Chi-square analysis.
[d]Probability of use by American robins was statistically significant for short-vegetation plots.
[e]Blackbirds comprised all blackbird species with the exception of eastern meadowlarks and was based on frequency in which constituent species appear in the FAA National Wildlife Strike Database (Cleary et al. 2005).
[f]Hazards = presence of blackbirds, eastern meadowlark, or European starling.

grackles), and northern flickers (*Colaptes auratus*). These species were the most commonly observed birds, and all except flickers have caused damaging strikes to both military and civil aircraft (Cleary et al. 2005). However, only robins showed a preference for short plots. The other species and blackbird group showed no preference for either tall or short-vegetation plots (Table 2).

Mammals

We captured no small mammals in short-vegetation plots during 2,925 adjusted trap nights. We captured 8 small mammals (7 meadow voles [*Microtus pennsylvanicus*], and 1 northern short-tailed shrew [*Blarina brevicauda*]) in tall-vegetation plots during 2,858 adjusted trap nights for an adjusted capture rate of 0.3/100 trap nights.

We found no difference ($Z = 1.96$; $P = 0.54$) in the number of mid-sized mammals observed in the plots during sunset and night counts. White-tailed deer was the most common species we observed, with 86 and 76 deer viewed in short- and tall-vegetation plots, respectively. We observed 1 and 3 raccoons (*Procyon lotor*) each in short- and tall-vegetation plots, respectively. Additionally, we observed 4 striped skunks (*Mephitis mephitis*) in tall-vegetation plots and 1 woodchuck (*Marmota monax*) in a short-vegetation plot. Similar numbers of deer and other mammals were seen during the sunset and night counts.

Arthropods

We dried the 2000 and 2001 arthropod samples using different regimens; therefore, data from the 2 years were not combined and are presented separately. During the 5 monthly sampling periods of 2000, we found 14 and 13 orders in short- and tall-vegetation plots, respectively. Homoptera (cicadas, aphids, planthoppers) were the most numerous individuals in both short- and tall-vegetation plots. Dried weight of arthropods captured/plot in 2000 differed ($Z = 2.85$; $P < 0.01$) between tall- ($\bar{x} = 0.65$ g, SE = 0.1) and short-vegetation ($\bar{x} = 0.32$ g, SE = 0.1) plots. In the 5 sampling periods of 2001, we found 14 and 19 orders in short- and tall-vegetation plots, respectively. Sixty percent of the samples for both short- and tall-vegetation plots were comprised equally of Arachnids (spiders), Coleoptera (beetles), Diptera (flies), Homoptera (cicadas, aphid, planthoppers), Hymenoptera (ants and bees), and Lepidoptera (butterflies and moths). The dry weight of the samples did

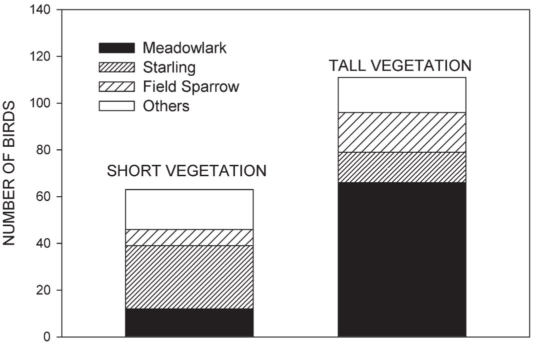

Figure 2. Number of birds flushed during 33 flush counts from short- and tall-vegetation plots that had not been counted during the 5-minute observation period immediately preceding the flush count, May19–October24, 2000, May1–October 30, 2001, and May23–July25, 2002, Plum Brook Station, Erie County, Ohio.

not differ ($Z = 1.84$; $P = 0.07$) between tall- ($\bar{x}$ = 0.11 g, SE = 0.01) and short-vegetation ($\bar{x}$ = 0.09 g, SE = 0.01) plots.

Discussion

Mowing vegetation plots at different heights affected vegetation structure and mammal use. The influence of vegetation height on insect biomass and bird use of the plots in this study is less clear. Although we observed more birds in short-vegetation plots, we flushed about 1.8 times more birds not accounted for in our surveys from tall-vegetation plots than from short-vegetation plots. Additionally, our analysis of avian group use based on presence and absence revealed no difference between treatments, with the exception of American robin preference for short vegetation.

Some researchers have theorized that flocking birds do not use tall vegetation because their vision is impeded and their vulnerability to predation is increased (Blokpoel 1976, Dekker and Van der Zee 1996). However, vegetation height alone may not explain variation in bird use of grasslands. Density of vegetation in addition to height may be an additional factor necessary to explain bird use of grasslands. For example, Norment et al. (1999) found that fields with shorter vegetation (i.e., ≤ 25 cm tall) supported more grassland birds than fields of tall vegetation. Additionally, in Great Britain, tall-grass management for bird reduction includes methods that enhance density of grass (Civil Aviation Authority 2002). Because the mean VOR in our tall-vegetation plots was 10.0 cm, it is possible that our tall-vegetation plots were of insufficient density to deter birds.

Barras et al. (2000) found higher bird and mammal use in unmowed areas than in mowed areas at an airport. Even infrequent mowing has been shown to at least temporarily reduce small mammal populations (Wilkins and Schmidly 1979, Lemen and Clausen 1984, Grimm and Yahner 1988, Edge et al. 1995). In this study, frequent mowing apparently reduced small mammal abundance. A reduced small mammal population decreases the habitat quality of an area to predatory mammals (e.g., coyotes [*Canis latrans*]) and raptors (e.g., red-tailed hawks), species that pose significant risks to aviation (Phelan and Robertson 1977, Baker and Brooks 1981*a*, Dolbeer et al. 2000). However, mowed areas that support a small mammal population are still preferred by predators over unmowed areas with denser small mammal populations because tall vegetation provides overhead protection for small mammals (Wakeley 1978, Baker and Brooks 1981b, Bechard 1982, Preston 1990, Sheffield et al. 2001, Fitzpatrick 2003).

Some grassland bird populations are declining as a result of habitat loss (Herkert 1994, Herkert et al. 1996, Blackwell and Dolbeer 2001, Sauer et al. 2002). Airports often provide some of the largest areas of grassland habitats available and are therefore attractive to grassland birds (Peterjohn and Rice 1991, Norment et al. 1999). However, should an airport be managed for tall vegetation, especially in the spring and summer, then American robin numbers might decline, while the numbers of grassland birds (e.g., eastern meadowlarks and upland sandpipers [*Bartramia longicauda*]) might increase (Herkert 1994, Davis 2005). This change in species composition, subsequent behavior, and overall bird numbers might be viewed as acceptable at some airports while not at others. Based on our study and that of Barras et al. (2000), we recommend that airports mow at least once every 4 weeks to reduce bird-aircraft collisions. This management strategy will not only reduce small mammal numbers (Wilkins and Schmidly 1979, Grimm and Yahner 1988), but also significantly reduce reproductive success of grassland birds (Bollinger et al. 1990, Frawley and Best 1991, Bowen and Kruse 1993, Kershner and Bollinger 1996).

The general recommendation that tall-vegetation management will remove bird problems from an airport is not consistent with our findings. Grassland birds have diverse

Sweeping a transect for arthropods.

habitat affinities and respond variably to habitat modifications (Herkert 1994). Overall, we found no difference in the number of birds using short- (9–15 cm) and tall-vegetation (15–30 cm) plots. Starlings readily used tall vegetation and were commonly observed foraging along edges of tall and short vegetation. Canada geese are commonly observed in tall vegetation, and in pen trials they used tall- and short-vegetation plots equally (Blackwell et al. 1999, Seamans et al. 1999). We did not observe gulls in our plots but have observed ring-billed gulls (*Larus delawarensis*) foraging in vegetation that was as high as their heads (Seamans unpublished data).

Mowing vegetation below 15 cm in late summer or early fall should discourage small mammal use of the area, thereby reducing use of the area by raptors and mammalian predators. Shorter vegetation also increases visibility of birds, thereby allowing bird control units to efficiently locate and disperse birds. However, biologists must monitor both bird and vegetative conditions at their airports when implementing any mowing plan. Birds commonly follow farm equipment involved in haying or plowing to feed on injured rodents, snakes, and insects. For this reason, mowing may have to be done at night when birds are less active.

Further, bird use of a habitat is influenced not only by vegetation height, but also season, plant physiology, and other factors (Davis 2005). However, dense, taller vegetation that restricts ground movement of birds might reduce bird numbers by making it difficult for them to forage (Norment et al. 1999, Sheffield et al. 2001). Specific vegetation types can also reduce foraging success within sites for many bird species (Linnell et al. 1995, Pochop et al. 1999, McCoy et al. 2001, Scott et al. 2002). We conclude that experiments combining dense vegetation growth with vegetation types that are known to be less desirable for grassland birds are necessary for a broader perspective on management of airfield grasslands. Such information would allow airfield managers to create an unattractive habitat for birds while maintaining an aesthetically pleasing view for the traveling public and ultimately improving aviation safety.

Conclusions

Because 90% of bird strikes occur on or near airports, habitat management on airfields is an important tool for the reduction of bird strikes. The data from this study indicate little to no difference in bird or mammal use of vegetation plots maintained by mowing either at short (9–15 cm) or tall (15–30 cm) heights. Thus, we suggest that each airport manage its vegetation based on the wildlife that uses the airport. Airport biologists should focus on the plant species, vegetation height, and plant density that will minimize the attractiveness of the airport to most hazardous wildlife species.

Acknowledgments.

We thank R. M. Puzak, National Aeronautics and Space Administration, Plum Brook Station, for providing access to the study site. R. Bush, L. Brohl, R. Dolbeer, Z. Patton, R. White, and S. Young provided field assistance. Sponsorship and funds for this research were provided in part by the Federal Aviation Administration (FAA). Opinions expressed in this study do not necessarily reflect current FAA policy decisions governing the control of wildlife on or near airports.

Literature cited

Baker, J. A., and R. J. Brooks. 1981*a*. Raptor and vole populations at an airport. Journal of Wildlife Management 45:390–396.

Baker, J. A., and R. J. Brooks. 1981*b*. Distribution patterns of raptors in relation to density of meadow voles. Condor 83:42–47.

Barras, S. C., R. A. Dolbeer, R. B. Chipman, G. E. Bernhardt, and M. S. Carrara. 2000. Bird and small mammal use of mowed and unmowed vegetation at John F. Kennedy International Airport, 1998–1999. Proceedings of the Vertebrate Pest Conference 19:31–36.

Bechard, M. J. 1982. Effect of vegetative cover on foraging site selection by Swainson's hawk. Condor 84:153–159.

Blackwell, B. F., and R. A. Dolbeer. 2001. Decline of the red-winged blackbird population in Ohio correlated to changes in agriculture (1965–1996). Journal of Wildlife Management 65:661–667.

Blackwell, B. F., T. W. Seamans, and R. A. Dolbeer. 1999. Plant growth regulator (Stronghold®) enhances repellency of anthraquinone formulation (Flight Control®) to Canada geese. Journal of Wildlife Management 63:1336–1343.

Blackwell, B. F., and S. E. Wright. 2006. Collisions of red-tailed hawks (*Buteo jamaicensis*), turkey (*Cathartes aura*), and black vultures (*Coragyps atratus*) with aircraft: implications for bird strike reduction. Journal of Raptor Research 40:76–80.

Blokpoel, H. 1976. Bird hazards to aircraft. Clarke, Irwin and Company and Canadian Wildlife Service, Ottawa, Canada.

Bollinger, E. K., P. B. Bollinger, and T. A. Gavin. 1990. Effects of hay-cropping on eastern populations of the bobolink. Wildlife Society Bulletin 18:142–150.

Bowen, B. S., and A. D. Kruse. 1993. Effects of grazing on nesting by upland sandpipers in southcentral North Dakota. Journal of Wildlife Management 57: 291–301.

Brough, T. E., and C. J. Bridgman. 1980. An evaluation of long-grass as a bird deterrent on British airfields. Journal of Applied Ecology 17:243–253.

Buckley, P. A., and M. G. McCarthy. 1994. Insects, vegetation, and the control of laughing gulls (*Larus atricilla*) at Kennedy International Airport, New York City. Journal of Applied Ecology 31:291–302.

Civil Aviation Authority. 2002. Aerodrome bird control. CAP 680. Aerodrome Standards Department, Safety Regulation Group. Gatwick Airport South, West Sussex, United Kingdom.

Cleary, E. C., R. A. Dolbeer, and S. E. Wright. 2005. Wildlife strikes to civilian aircraft in the United States, 1990–2004. Federal Aviation Administration, Wildlife Aircraft Strike Database Serial Report Number 11. Washington, D.C., USA.

Davis, S. K. 2005. Nest-site selection patterns and the influence of vegetation on nest survival of mixed-grass prairie passerines. Condor 107:605–616.

Dekker, A., and F. F. van der Zee. 1996. Birds and grassland on airports. Bird Strike Committee Europe 23:291–305.

Delisle, J. M, and J. A. Savidge. 1997. Avian use and vegetation characteristics of Conservation Reserve Program fields. Journal of Wildlife Management 61:318–325.

Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. Ranking the hazard level of wildlife species to aviation. Wildlife Society Bulletin 28:372–378.

Edge, W. D., J. O. Wolff, and R. L. Carey. 1995. Density-dependent responses of gray-tailed voles to mowing. Journal of Wildlife Management 59:245–251.

Fitzpatrick, K. J. 2003. Effects of mowing on the selection of raptor foraging habitat. Dissertation, University of Maryland, College Park, Maryland, USA.

Frawley, B. J., and L. B. Best. 1991. Effects of mowing on breeding bird abundance and species composition in alfalfa fields. Wildlife Society Bulletin 19:135–142.

Grimm, J. W., and R. H. Yahner. 1988. Small mammal response to roadside habitat management in south central Minnesota. Journal of the Minnesota Academy of Science 53:16–21.

Hedeker, D., and R. D. Gibbons. 2006. Longitudinal data analysis. Wiley-Interscience, Hoboken, New Jersey, USA.

Herkert, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4:461–471.

Herkert, J. R., D. W. Sample, and R. E. Warner. 1996. Management of midwestern grassland landscapes for the conservation of migratory birds. U.S. Forest Service General Technical Report NC 187:89–116.

Johnson, D. H., and L. D. Igl. 2001. Area requirements of grassland birds: a regional perspective. Auk 118:24–34.

Kershner, E. L., and E. K. Bollinger. 1996. Reproductive success of grassland birds at east-central Illinois airports. American Midland Naturalist 136:358–366.

Lemen, C. A., and M. K. Clausen. 1984. The effect of mowing on the rodent community of a native tall grass prairie in eastern Nebraska. Prairie Naturalist 16:5–10.

Linnell, M. A., M. R. Conover, and T. J. Ohashi. 1995. Wedelia: a potential ground cover for reducing the attractiveness of tropical airfields to birds. Proceedings of the Great Plains Wildlife Damage Control Workshop 12:10–13.

McCoy, T. D., M. R. Ryan, and L. W. Burger, Jr. 2001. Grassland bird conservation: CP1 vs. CP2 plantings in Conservation Reserve Program fields in Missouri. American Midland Naturalist 145:1–17.

Mead, H., and A. W. Carter. 1973. The management of long grass as a bird repellent on airfields. Journal of British Grassland Society 28:219–221.

Norment, C. J., C. D. Ardizzone, and K. Hartman. 1999. Habitat relations and breeding biology of grassland birds in New York. Studies in Avian Biology 19:112–121.

Peterjohn, B. G., and D. L. Rice. 1991. The Ohio breeding bird atlas. Ohio Department of Natural Resources, Columbus, Ohio, USA.

Phelan, F. S., and R. J. Robertson. 1977. Predatory responses of a raptor guild to changes in prey density. Canadian Journal of Zoology 56:2565–2572.

Pochop, P. A., J. L. Cummings, K. L. Wedemeyer, R. M. Engeman, and J. E. Davis, Jr. 1999. Vegetation preferences of captive Canada geese at Elmendorf Air Force Base, Alaska. Wildlife Society Bulletin 27:734–740.

Preston, C. R. 1990. Distribution of raptor foraging in relation to prey biomass and habitat structure. Condor 92:107–112.

Rose, J., and J. D. Harder. 1985. Seasonal feeding habits of an enclosed high density white-tailed deer herd in northern Ohio. Ohio Journal of Science 85:184–190.

SAS Institute. 2001. SAS System for Windows V8(2). SAS Institute, Cary, North Carolina, USA.

Sauer, J. R., J. E. Hines, and J. Fallon. 2002. The North American breeding bird survey, results and analysis 1966–2001. Version 2002.1, U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Scott, P. E., T. L. DeVault, R. A. Bajema, and S. L. Lima. 2002. Grassland vegetation and bird abundances on reclaimed midwestern coal mines. Wildlife Society Bulletin 30:1006–1014.

Seamans, T. W., R. A. Dolbeer, M. S. Carrara, and R. B. Chipman. 1999. Does tall grass reduce bird numbers on airports?: Results of pen test with Canada geese and field trials at two airports, 1998. Pages 160–170 *in* Proceedings Joint Meeting of Bird Strike Committee Canada and Bird Strike Committee USA, Vancouver, British Columbia, Canada.

Sheffield, L. M., J. R. Crait, W. D. Edge, and G. Wang. 2001. Response of American kestrels and gray-tailed voles to vegetation height and supplemental perches. Canadian Journal of Zoology 79:380–385.

Solman, V. E. F. 1966. Ecological control of bird hazard to aircraft. Proceedings of the Bird Control Seminar 3:38–56.

Transport Canada. 1994. Wildlife control procedures manual. Environmental and Support Services, Airports Group. TP11500E. Ottawa, Canada.

U.S. Department of Agriculture. 1998. Managing wildlife hazards at airports. Animal and Plant Health Inspection Service, Wildlife Services, Washington, D.C., USA.

U.S. Department of Transportation. 1993. Airport wildlife hazard management. AC 150/5200-32. Federal Aviation Administration, Office of Airport Safety and Standards, Washington, D.C., USA.

Wakeley, J. S. 1978. Factors affecting the use of hunting sites by ferruginous hawks. Condor 80:316–326.

Wilkins, K. T., and D. J. Schmidly. 1979. The effects of mowing highway rights-of-way on small mammals. Pages 55-1–55-13 *in* Proceedings of the Second Symposium on Environmental Concerns in Rights-of-way Management, Ann Arbor, Michigan, USA.

Wright, S. E. 2001. An analysis of deer strikes with civil aircraft, USA, 1982–2000. Proceedings Bird Strike 2001:31–41.

Wright, S. E., R. A. Dolbeer, and A. J. Montoney. 1998. Deer on airports: an accident waiting to happen. Proceedings of the Vertebrate Pest Conference 18:90–95.

Zeger, S. L., and K. Y. Liang. 1986. Longitudinal data analysis for discrete and continuous outcomes. Biometrics 42:121–130.

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LEFT TO RIGHT: Thomas Seamans, Brad Blackwell, Glen Bernhardt.

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